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SOVIET VIEW OF LASER WEAPONS

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INTRODUCTION

This is a translated excerpt of a recent article on laser weapons appearing in the Soviet military journal Tekhnika i vooruzheniye (Engineering and Armament). The treatment is general, and claims to be based on non-Soviet technology.

Vetrov, V. (Maj. General) and N. Sokolov (Colonel). Laser weapons. Tekhnika i vooruzheniye, no. 3, 1974.

This article begins with a general review of the physics of lasers, followed by a discussion of possible applications of high-power lasers to warfare. The material is all attributed to "foreign publications" without any source being cited. As customary in treatments of this sort, the authors imply repeatedly that it is the capitalist countries who are responsible for laser weapon development.

Following is a translation of the portion of article which directly refers to laser weapon technology.

"Scientific research performed in various countries has proven, theoretically and experimentally, that laser emission can be employed in designing basically new types of weapons. The physical properties of such weapons and their destructive characteristics have already been determined. The fundamental destructive factor is the sharp pencil-type emission of e-m energy in the optical range. With sufficiently powerful emission the released energy interacts with the target and from the high pressure and temperature it causes penetration, overheating, melting and evaporation of the target material. It is generally believed that such weapons could be applied, according to foreign opinions, for blinding enemy personnel; for the destruction of optical and electronic apparatus (optical observation devices or photosensitive I-R cells, TV and laser instrumentation); or for hitting inflammable objects in the battlefield as well as low-flying airborne targets.

"According to foreign specialists, laser weapons possess a number of advantages over many conventional means of destruction. The most obvious advantages are: instantaneous effect on enemy objects,

high pointing accuracy, and noiseless impact. The high degree of accuracy is achieved through the different method of aiming with laser weapons, since in this case it is not necessary to allow for the speed of the moving target or to compute the intersection point of the beam and the target; nor is it necessary to make any ballistic adjustments. As a means of destruction all laser weapons have an additional advantage: the powerful energy flux can be produced by the generator directly on the battlefield.

"It might be well to point out that laser weapons have also certain disadvantages: the destructive impact of radiant energy can only be used within the range of direct visibility; and propagation is strongly influenced by atmosphere, precipitation (rain, snow, dense fog) and aerosol particles suspended in air. Despite these disadvantages several capitalist countries are engaged in research, experimental work and designing of laser weapons for land, naval and air forces. Foreign experts concur that there are still numerous scientific and technological problems to be solved and that some 7-10 years would be needed to surmount these difficulties.

"Among the unsolved problems two are of particular importance: search for and mastering of those sectors of the optical range that are most promising for the transmission of laser emission in the atmospheric boundary layer; and increasing the transmitted energy. The first problem is due to the fact that laser beams passing through the atmosphere are attenuated by it, the main reason for this being the absorption of radiant energy by air molecules. This absorption is in inverse proportion to the fourth power of the emitted wavelength. Because of this the atmosphere is practically opaque to the shortwave sector of e-m emission, beginning with the ultraviolet region ($\lambda = 0.35\ \mu$).

"In the visible and infrared regions of laser emission ($\lambda = 0.4$ to $300\ \mu$) we may encounter absorption bands, which are the result of water vapor and carbon dioxide in the atmosphere. In other words, there are only a few regions with good transmitting capacity, the so-called windows of transmissivity. The best explored region of atmospheric transmissivity

coincides with the maximum light response of the human eye, in the interval of 0.4 - 0.8 μ. We have several such windows in the infrared region, in the wavelength ranges of 1.25 - 1.8 μ, 3.5 - 4.5 μ, and a very large window in the interval of 8 - 12 μ. From the point of view of transmissibility the most promising are the latter two windows.

"There are two additional phenomena that degrade laser emission of high intensity. One of these is the so-called "thermal spreading", which is typical of lasers operating in a c-w regime. This spreading produces an atmospheric lens effect which causes distorting and bending of the beam and dissipation of the energy; as a result energy density is attenuated and the beam deviates from the target. The second phenomenon observed in the emission of powerful lasers operating in a pulsed regime, is air ionization resulting in the formation of plasma capable of absorbing the emission energy and thus blocking the beam propagation toward the target.

"Attenuation of laser emission is also caused by its dispersion and absorption by aerosols, i.e. small particles of dust and smog suspended in the air. It is well known that various aerosols are employed in combat in the form of artificial smoke or fog. Many foreign experts believe, however, that owing to its high energy density a laser beam should be capable of passing through atmosphere, clouds, fogs and smoke. They also emphasize that the impact of air turbulence, fluctuations of air layers and atmospheric turbidity on the propagation of powerful laser emission has been explored in only a crude way. Along with the study of properties of the atmosphere, foreign specialists continue their efforts to increase the intensity of laser emission. At the present time weapons are being designed using both solid-state and gas lasers. It is believed that solid-state lasers, because of their limitations, can only be employed in low-power weapons, e.g. for destroying photoreceivers of electro-optical devices. The highest energy level obtained thus far (1972) in this type of laser under steady-state conditions is 600 joules. For pumping such lasers only limited power can be applied, since any further increase would destroy their active elements.

"Foreign experts pin their hopes on gasdynamic, electro-aerodynamic, and chemical lasers, which are considered to offer most promise for more powerful weaponry. (Reference is made to Tekhnika i vooruzheniye, no. 10, 1972). According to theoretical calculations, gasdynamic lasers are capable of generating c-w emission of the order of several tens of kilowatts, as shown in the table below.

Type of Laser	Wavelength in Microns	Operating Mode	Gas	Emission Power, Watts	Emission Energy, Joules	Pulse Duration, Seconds
Gas	10.6	pulsed	CO_2	10^8	10	10^{-7}
Gas	10.6	pulsed	CO_2	$3.6x10^6$	24	$6x10^{-6}$
Chemical	10.6	c-w	CO_2	$6x10^3$	-	-
Electroaero-dynamic	10.6	c-w	CO_2	$19.1x10^3$	-	-
Gasdynamic	10.6	c-w	CO_2	$6x10^4$	-	-

"Foreign experts claim that laser weapons should be designed to operate in a pulsed rather than a c-w regime; the pulsed regime gives a discrete shooting effect which in turn lowers its identification vulnerability. It is believed that for such purposes, potentially suitable pulsed lasers can operate in the following sectors of the optical range: ruby lasers at $\lambda = 0.69\ \mu$; neodymium glass lasers at $\lambda = 1.06\ \mu$; and gas-dynamic, electrodynamic and chemical lasers at $\lambda = 10.6\ \mu$.

"As already mentioned, tactical laser weapons operate over the range of direct visibility. All targets to be destroyed are divided by foreign military experts into three groups. The first group comprises the actual enemy personnel. The most vulnerable factor here is the eyesight since laser emission causes blinding. In this case only a relatively low level of destructive energy density is needed. The maximum tolerable energy density of laser emission that is safe for the human eye is 2.5×10^{-7} joule/cm^2; even energy densities of 10^{-4} to 10^{-5} joule/cm^2 leads to blinding. The second group of targets consists of photodetectors in electrooptical devices; here the vulnerable part is the photosensitive cell. Low-flying airborne targets comprise the third group. In this category, laser weapons have the following effect. laser emission destroys the outer skin of airborne targets at any given area. It is pointed out that in order to achieve this it is necessary to have power density at the target equal to 10^7 watt/cm^2.

"It is evident that any increase in the divergence angle tends to increase the density of the energy required. Selection of the optimal divergence angle depends on the size and weight of the optical equipment used for the formation of the laser beam. The smaller the angle of divergence, the larger must be the size of the optical elements. It should also be added that a very small angle of divergence makes it more difficult to hit the target, since in this case the beam cross-section is also very small. For instance, with an angle of divergence of 0.1 milliradian the diameter of a spot 1 km away is 10 cm; at 2 km away, 20 cm. From testing various compromise solutions, it is concluded that the optimal angle of divergence should be 0.5 milliradian.

"When determining the emission energy needed for the destruction of low-flying airborne targets it is necessary to account for the fact that laser emission propagates through the atmospheric boundary layer, and that part of the incident energy does not affect the object, since the object possesses reflecting capability. Foreign experts believe that a certain amount

of energy is going to be reflected before interacting with the target. Hence the energy required for the destruction of a low-flying target should be about 10^7 joule, at a pulse length of 10^{-3} sec.

"The basis of any laser weapon should be a powerful laser that delivers useful output energy. Furthermore, the device must comprise the optical system of beam formation, power supply and finally optical instrumentation for guidance toward the target under both day and night conditiors. In using the weapon against low-flying airborne targets moving at high speed it is advisable to employ an automatic guidance system equipped with a combination of radar and optical devices, since under conditions of poor visibility the radar should have a high degree of guidance accuracy and resolution capability."